AD-A094 477 MINNESOTA UNIV MINNEAPOLIS COMPUTERIZED ADAPTIVE TES--ETC F/G 5/10
AN ALTERNATE-FORMS RELIABILITY AND CONCURRENT VALIDITY COMPARIS--ETC(U)
DEC 80 G G KINGSBURY, D J WEISS N00014-76-C-0243

UNCLASSIFIED RR-80-5 NL

1 OF 1
AD A
094477

END
DATE
FILMED
2-81
DTIC

(12)

An Alternate-Forms Reliability and Concurrent Validity Comparison of Bayesian Adaptive and Conventional Ability Tests

G. Gage Kingsbury
and
David J. Weiss

Research Report 80-5
December 1980

Computerized Adaptive Testing Laboratory
Psychometric Methods Program
Department of Psychology
University of Minnesota
Minneapolis, MN 55455

This research was supported by funds from the Air Force Office of Scientific Research, the Army Research Institute, the Air Force Human Resources Laboratory, and the Office of Naval Research, and monitored by the Office of Naval Research.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(16) RR04204

(9)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER Research Report 80-5	2. GOVT ACCESSION NO. AD-A094477
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) (6) An Alternate-Forms Reliability and Concurrent Validity Comparison of Bayesian Adaptive and Conventional Ability Tests.	5. TYPE OF REPORT & PERIOD COVERED Technical Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) G. Gage Kingsbury ~~and~~ David J. Weiss	8. CONTRACT OR GRANT NUMBER(s) (15) N00014-76-C-0243, N00014-79-C-0172
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Psychology University of Minnesota Minneapolis, Minnesota 55455	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS PE: 6115N Proj: RR042-04 TA: RR042-04-01 WU: NR150-382, 150-433
11. CONTROLLING OFFICE NAME AND ADDRESS Personnel and Training Research Programs Office of Naval Research Arlington, Virginia 22217	12. REPORT DATE (11) December 1980 13. NUMBER OF PAGES 20
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (17) RR0420401	15. SECURITY CLASS. (of this report) Unclassified (12) 24 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited. Reproduction in whole or in part is permitted for any purpose of the United States Government.

(14) RR-80-5

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This research was supported by funds from the Army Research Institute, the Air Force Human Resources Laboratory, the Air Force Office of Scientific Research, and the Office of Naval Research, and monitored by the Office of Naval Research.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computerized Testing	Response-Contingent Testing	Ability Testing
Adaptive Testing	Latent Trait Test Theory	
Tailored Testing	Item Characteristic Curve Theory	
Sequential Testing	Item Response Theory	
Individualized Testing	Bayesian Testing	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Two 30-item alternate forms of a conventional test and a Bayesian adaptive test were administered by computer to 472 undergraduate psychology students. In addition, each student completed a 120-item paper-and-pencil test, which served as a concurrent validity criterion test, and a series of very easy questions designed to detect students who were not answering conscientiously. All test items were five-alternative multiple-choice vocabulary items.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

Unclassified 411701

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Reliability and concurrent validity of the two testing strategies were evaluated after the administration of each item for each of the tests, so that trends indicating differences in the testing strategies as a function of test length could be detected. For each test, additional analyses were conducted to determine whether the two forms of the test were operationally alternate forms.

Results of the analysis of alternate-forms correspondence indicated that for all test lengths greater than 10 items, each of the alternate forms for the two test types resulted in fairly constant mean ability level estimates. When the scoring procedure was equated, the mean ability levels estimated from the two forms of the conventional test differed to a greater extent than those estimated from the two forms of the Bayesian adaptive test.

The alternate-forms reliability analysis indicated that the two forms of the Bayesian test resulted in more reliable scores than the two forms of the conventional test for all test lengths greater than two items. This result was observed when the conventional test was scored either by the Bayesian or proportion-correct method.

The concurrent validity analysis showed that the conventional test produced ability level estimates that correlated more highly with the criterion test scores than did the Bayesian test for all lengths greater than four items. This result was observed for both scoring procedures used with the conventional test.

Limitations of the study, and the conclusions that may be drawn from it, are discussed. These limitations, which may have affected the results of this study, included possible differences in the alternate forms used within the two testing strategies, the relatively small calibration samples used to estimate the ICC parameters for the items used in the study, and method variance in the conventional tests.

CONTENTS

An Alternate-Forms Reliability and Concurrent Validity Comparison of Bayesian Adaptive and Conventional Ability Tests

The potential advantages of the use of computerized adaptive testing to more effectively assess individuals' ability levels have been pointed out by a number of researchers (e.g., Lord, 1977a; Urry, 1977; Weiss, 1974; Weiss & Betz, 1973). The most widely used approaches to adaptive testing use item characteristic curve or item response theory (IRT; Lord & Novick, 1968) to adapt a test given to an individual to his or her trait level by administering items with characteristics that allow very efficient measurement. A number of research studies have been concerned with how well the potential advantages of adaptive testing are borne out in live studies (e.g., Bejar & Weiss, 1978; Betz & Weiss, 1975; Larkin & Weiss, 1974; Thompson & Weiss, 1980).

One type of procedure used for adapting test characteristics is a Bayesian algorithm for adaptive testing developed by Owen (1969, 1975). This Bayesian procedure has been studied in both monte carlo simulation and live studies (e.g., Jensema, 1974; McBride & Weiss, 1976, 1977; Urry, 1971), which have attempted to explicate the properties of the testing strategy. In many of these studies, however, testing strategies were evaluated using criteria derived from IRT rather than using classical reliability and validity concepts. The present study investigated how well this Bayesian adaptive testing procedure performed relative to a conventional testing strategy, using two classical psychometric indices of test performance.

Method

Owen's Bayesian adaptive testing strategy was compared in two ways to a conventional testing strategy. After each item was administered, the two testing strategies were compared in terms of (1) their alternate-forms reliability and (2) their concurrent validity.

Subjects

The subjects taking part in this study were 472 undergraduate students at the University of Minnesota. These students volunteered to take part in the study as partial fulfillment of the requirements of the general psychology course in which they were enrolled. Subjects were recruited and tested during the winter and spring academic quarters of 1976.

Test Administration

Each volunteer took each of the following vocabulary ability tests during the testing session:

1. A 120-item conventional test administered in paper and pencil format.
2. Two 30-item conventional tests administered by computer and designed to be parallel tests.

3. Two 30-item Bayesian adaptive tests administered by computer and designed to be parallel tests.
4. Three 3-item "catch trials" administered by computer and consisting of extremely easy questions.

All of the 249 items administered during the testing session were five-alternative multiple-choice items.

Each student began the testing session by taking the 120-item conventional test. Scores on this test served as the criterion against which the relative validities of the two types of computer-administered tests were judged.

Following the criterion test, the order of administration of the two types of computer-administered tests was counterbalanced. Half of the students were given the two parallel forms of the Bayesian adaptive test, followed by the two forms of the conventional test; the other half received the conventional tests first, followed by the Bayesian tests.

For both the conventional and Bayesian tests, the two parallel forms were administered as close to simultaneously as possible. To operationalize this, an ABBA rotation was used; that is, one item was administered from Form A to begin the test, followed by two items from Form B, followed by two items from Form A. For each individual the prior distribution specified at the beginning of each of the Bayesian test forms had a mean of 0.0 and a standard deviation of 1.0.

Three catch trials consisting of three very easy items each were included during the computer-administered testing period. These catch trials were designed to identify students who were exceptionally careless, who deliberately responded incorrectly, or who did not understand the instructions. Once these individuals were identified, they would be marked as having inappropriate response patterns.

The catch trial items were not separated in any way from the actual tests. The first catch trial consisted of the first three items administered by the computer. The second catch trial occurred at the middle of the computerized test session (i.e., between the two different types of computer-administered tests). The third catch trial consisted of the last three items administered by the computer.

Test Design and Scoring

Criterion test. The criterion test administered to the students consisted of 120 vocabulary questions taken from Part III of Forms 2A, 2B, 3A, and 3B of the Cooperative School and College Ability Tests (SCAT I). This test was a portion of the item pool described by Lord (1977b) as a broad-range item pool for the measurement of verbal ability. The items were five-alternative multiple-choice questions which had been extensively normed and for which item parameter estimates from the three-parameter normal ogive IRT model were available. The parameter estimates for the items making up the criterion test are shown in Appendix Table A. The criterion test was scored using Owen's IRT-based Bayesian scoring method.

Conventional tests. The two conventional test forms were designed to be parallel tests, peaked at an average ability level. An item pool, which contained 577 five-alternative multiple-choice vocabulary items (McBride & Weiss, 1974), was available for use. For each of these items, estimates of the a (item discrimination) and b (item difficulty) parameters, which had earlier been calculated using Jensema's (1976) approximation procedure, were available. Since each of the items had five choices, the estimate of c (the lower asymptote parameter) had been set at .20 for each item. The method used to calculate item parameter estimates, corrected for guessing, is described by Prestwood and Weiss (1977).

From this large item pool, 120 items were selected that had the highest available information at the ability level (θ) of 0.0 with difficulty estimates between -1.0 and +1.0. These 120 items were further subdivided into two 60-item pools equated for available information at θ=0.0. One of these 60-item pools was used as a portion of the Bayesian testing pool (described below), and the other was used to construct the two alternate forms of the conventional test.

The two 30-item forms of the conventional test were constructed from the 60-item pool in order to equate as closely as possible the amount of information available at θ=0.0 in each form after each item was administered. Thus, the first item chosen for Form A was the most informative item at θ=0.0, the next two most informative items at θ=0.0 were chosen to serve as the first two items of Form B, then the next two most informative items were chosen as the next two items for Form A, and so on until the last item in the 60-item pool was chosen to serve as the last item of Form A. The parameter estimates for the items making up each of the conventional test forms are shown in Appendix Table B in the order of their administration.

Conventional tests were scored by proportion correct at each test length from 1 to 30 items. In addition, to maximize comparability with the IRT-scored Bayesian adaptive test, the conventional tests were also scored by Owen's Bayesian scoring method, and scores were recorded at all test lengths.

Bayesian adaptive tests. The two Bayesian adaptive test forms both drew items from a single 180-item pool in the ABBA fashion described above. For any one individual, a given item appeared only on one form (if at all); but across individuals, a single item might have appeared on Form A for one person, Form B for another person, and neither form for a third person.

Sixty of the items in the 180-item Bayesian item pool came from the 60-item pool developed as described above. The additional 120 items were selected from the remainder of the original 577-item pool. The items that were chosen were 6 groups of 20 items each that provided the most information at 6 ability levels (θ=-2.0, -1.5, -1.0, 1.0, 1.5, 2.0). The parameter estimates for the 180 items in the final Bayesian testing pool are shown in Appendix Table C.

The Bayesian adaptive test ability estimates were recorded for each of the two dynamically administered parallel forms at each test length from 1 to 30 items.

Analyses

Catch trial analysis. Prior to all other analyses, those subjects who failed to correctly answer at least seven of the nine items administered during the catch trials were removed from further analyses. This was intended to identify those subjects who incorrectly answered these extremely easy items, thus indicating that they either misunderstood the instructions, were deliberately answering incorrectly, or were careless. Once these individuals were identified, a more detailed analysis of their response patterns was planned to determine whether the catch trials had performed successfully (i.e., had detected individuals with very inconsistent response patterns).

Correspondence of test forms. The two forms of the conventional test were designed to measure vocabulary ability in the same manner with approximately the same precision, especially for individuals with average ability levels (θ=0.0). To determine whether the design had been satisfactorily achieved, three criteria were used. First, the theoretical test information functions (Birnbaum, 1968) for the two forms were calculated and inspected for differences in their general shape and in the amount of information available at θ=0.0. (The theoretical information function serves as an upper bound to the amount of information which may be recovered from the items. The actual information recovered is a function of the scoring procedure employed.)

The second criterion was the mean Bayesian ability estimate computed within the testing sample after each item was administered within each test form. This was a reasonable criterion because at every test length the test forms were designed to measure the same ability with an equal degree of precision. To the extent that the two forms did not produce the same mean ability estimate for the same group of people, it could be concluded that the two test forms were not measuring in the same manner.

The third criterion used to evaluate the equivalence of the two conventional test forms was the mean proportion of items answered correctly within the testing sample after each item was administered within each test form. The rationale behind this criterion was the same as that used for the second criterion, except that the more widely used proportion-correct scoring system was used here in place of the Bayesian ability estimation procedure.

For the Bayesian test forms, the item selection procedure used in this study was designed to result in two test forms that measured the same ability with approximately the same precision after each item was administered by the two forms. To determine the effectiveness of this design in terms of equalizing the two Bayesian test forms, the first and third criteria used for the analysis of the conventional test forms were inappropriate. The first criterion was inappropriate since the theoretical test information functions for the two forms would be different for each person taking the adaptive tests; and the third was inappropriate because the observed proportion correct is not an estimate of an individual's true ability level within the context of an adaptive test. Consequently, for the Bayesian test forms the equivalence of the two forms was examined by observing the differences in the mean Bayesian ability estimate obtained from the two test forms, following the administration of each item to the students.

Alternate forms reliability. The two testing strategies were compared in terms of the alternate forms reliability of the ability level estimates obtained for individuals from the two alternate test forms. Specifically, Pearson product-moment correlations were calculated between the ability level estimates obtained from the alternate test forms at all test lengths from 1 to 30 items. For the conventional test, two different ability level estimates were available--proportion correct and Bayesian. Therefore, two different alternate-forms reliability coefficients were computed at each conventional test length.

Concurrent validity. Bayesian ability level estimates were obtained for each subject based on their responses to the 120-item paper-and-pencil criterion test. Correlations between the ability level estimates obtained from the various computer-administered tests and the criterion test ability estimates were calculated at each possible test length, for each computer-administered test form.

For the Bayesian test, 30 validity coefficients were calculated for each of the two test forms. Similarly, for the conventional test, 30 validity coefficients were calculated for each of the four combinations of a scoring strategy and a test form. To facilitate the comparison of the two testing strategies and to attain more stable estimates of validity, validity coefficients that resulted from the alternate forms of the same test type using the same scoring strategy were averaged across test forms at each test length.

Results

Catch Trial Analysis

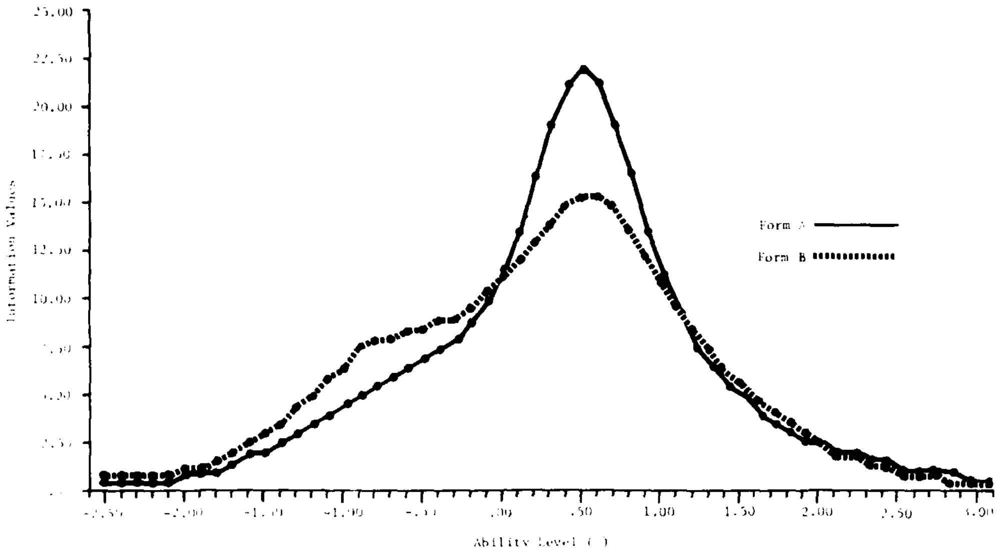
Of the 472 students in the testing sample, none failed to correctly answer at least seven of the catch trial items. Thus, none of the students' response patterns were removed from the data set used in the analyses reported below. In the entire testing sample, 95% of the students answered all nine of the catch trial items correctly. The other 5% of the sample correctly answered eight of the nine catch trial questions. No individual answered less than eight of the questions correctly.

Correspondence of Test Forms

The theoretical test information functions (i.e., the sums of the item information functions) for Forms A and B of the conventional test are shown in Figure 1. It can be seen from this figure that each of the test forms was fairly sharply peaked. For both forms the information peak was reached between $\theta=.5$ and .6. The information peak calculated for Form A, 21.90 information units (IU), was higher than that for Form B, 15.66 IU. At the ability level at which the two test forms were designed to provide the same amount of information, $\theta=0.0$, Form A had a potential of 11.580 IU, and Form B had a potential of 11.055 IU. In terms of their information potential, the two conventional test forms conformed to their design specifications fairly well and should have resulted in approximately equally precise ability estimates for ability levels near $\theta=0.0$.

Figure 2 shows the mean proportion of correct answers observed within the

Figure 1
Theoretical Information Available from Forms A and B
of the Conventional Test, as a Function of Ability Level



testing sample after each item was administered within the conventional test, for both Forms A and B. It can be seen from this figure that the mean observed proportion correct for each of the test forms varied somewhat for test lengths up to about 10 items. For Form A the highest mean proportion correct (.55) was observed following the administration of the third item, and the lowest mean proportion correct (.32) was observed following the administration of the first item. For Form B the highest and lowest mean proportion-correct values (.57 and .41) were observed following the first and third items, respectively. Following this initial fluctuation, each test form resulted in quite consistent observations of the mean proportion-correct values at all longer test lengths. Following the first 10 items, the highest mean proportion correct observed for Form A was .50 following Item 12, and the lowest was .47 following Item 21. For Form B, after the first 10 items, the highest and lowest mean proportion-correct values were .55 and .52, following Item 22 and Item 17, respectively. Form A resulted in a mean proportion-correct value of .48 after all 30 items were administered, whereas Form B resulted in a value of .53.

Figure 3 shows the mean Bayesian ability level estimate observed across the testing sample within each of the conventional test forms, following the administration of each item. The pattern of Bayesian ability level estimates shown in Figure 3 is very similar to that of the pattern of mean proportion-correct values in Figure 2. As in the proportion-correct analysis, the mean Bayesian ability level estimates for each form were most variable in the first third of the test, becoming much less variable as the test proceeded. For Form A the highest mean Bayesian ability level estimate that was observed was -.13, following the third item, whereas the lowest mean estimate was -.44, following the 18th item. For Form B, the highest mean estimate was .02, after the first item, and the lowest estimate was -.31, following the 15th item. After 30 items were administered for each of the conventional test forms, the mean ability estimate observed was -.40 for Form A and -.28 for Form B.

Figure 2
Mean Proportion of Items Answered Correctly for Two Conventional Test Forms, as a Function of Number of Items Administered

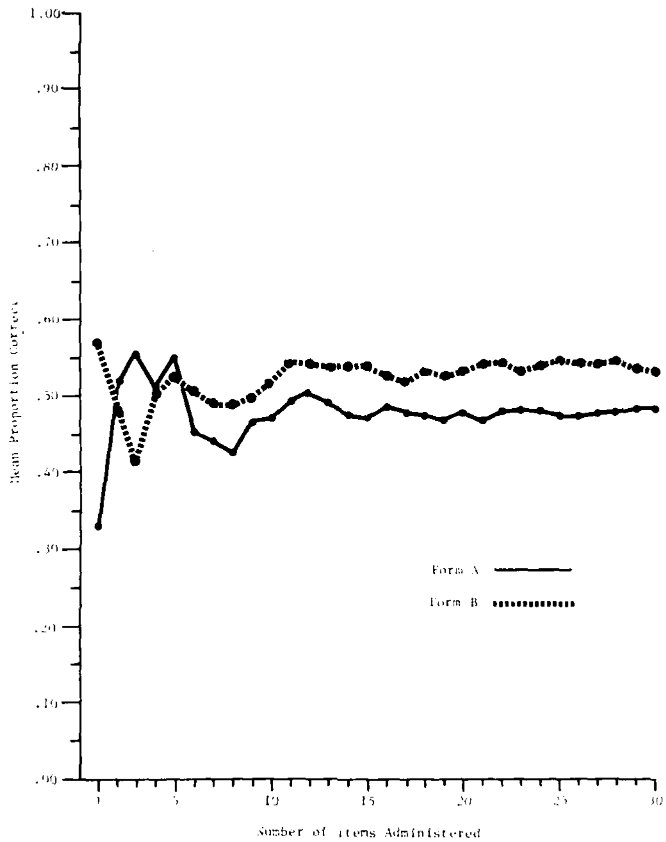
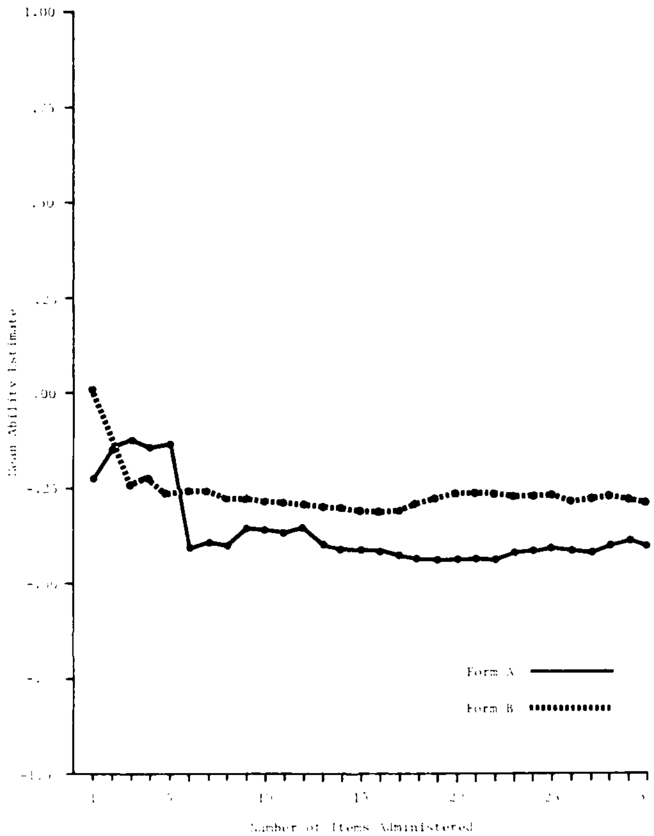


Figure 4 shows the mean Bayesian ability level estimate observed within the testing sample following the administration of each item on each of the forms of the Bayesian adaptive test. For Form A the highest mean ability estimate observed was -.27, following the 13th item. The lowest mean ability estimate for Form A was -.36, after the second item was administered. For Form B the range of the mean ability estimates was from -.03 to -.29. These estimates were observed following the first and last items, respectively. Following the administration of the final item from each of the Bayesian test forms, the mean ability level estimate observed was -.32 for Form A and -.29 for Form B.

Alternate Forms Reliability

Figure 5 shows the Pearson product-moment correlations between the ability level estimates obtained from the two forms of the conventional test using the Bayesian scoring strategy and proportion-correct scoring strategy and from the two forms of the Bayesian test using the Bayesian scoring strategy (the numerical values are shown in Appendix Table D). These correlations serve as estimates of the alternate-forms reliabilities of the different test types. The most obvious result reflected in this figure is that except for the first two items administered, the Bayesian adaptive test resulted in higher alternate

Figure 3
Mean Bayesian Ability Level Estimates for Two Conventional Test Forms, as a Function of Number of Items Administered



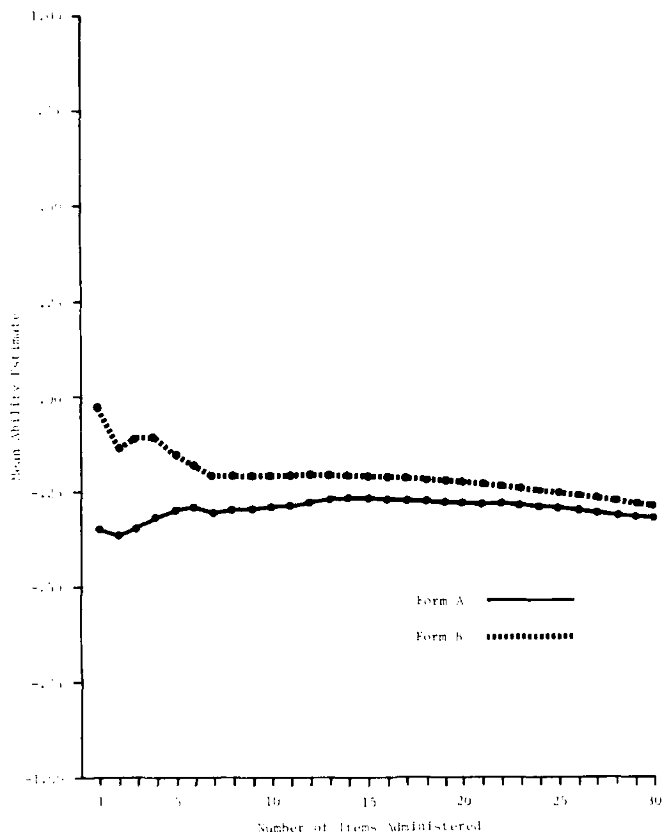
forms reliability than the conventional test at all test lengths, regardless of the scoring method used for the conventional test. Further, the difference in reliability between the two testing strategies increased as the length of the tests increased from 10 to 30 items. Following the administration of the final item, the reliability of the Bayesian test was .920, whereas for the conventional test the reliabilities observed were .879 and .868, respectively, for the proportion-correct and Bayesian scoring strategies.

Another result shown in Figure 5 is that both the Bayesian and proportion-correct scoring strategies resulted in very similar reliabilities for the conventional test. This finding is counter to expectation, since a scoring strategy that uses information concerning differences among the items when scoring should result in more reliable ability level estimates than a scoring system that treats all of the items as if they were the same.

Concurrent Validity

Figure 6 shows the mean Pearson product-moment correlations between the Bayesian ability level estimates derived for the testing sample from the

Figure 4
Mean Bayesian Ability Level Estimate for Two Bayesian Test Forms, as a Function of Number of Items Administered

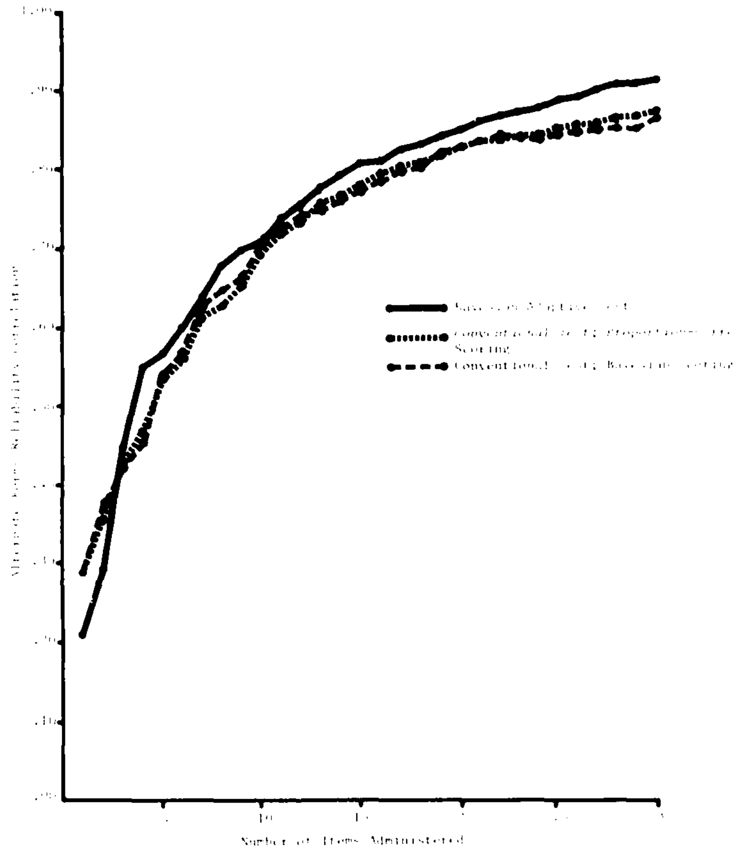


120-item paper-and-pencil criterion test and the ability estimates derived from the Bayesian and conventional tests, across all test lengths (numerical values are shown in Appendix Table E). The conventional test forms were again scored using both the proportion-correct scoring system and the Bayesian scoring system. As was indicated above, the values shown in Figure 6 are mean correlations, averaged across the two forms of the test involved.

From Figure 6, the first trend observed is that for all test lengths greater than four items, the conventional test scores were more highly correlated with the criterion scores than were the scores derived from the Bayesian adaptive test forms. Following the final item, the Bayesian adaptive test scores resulted in a criterion test correlation of .797, the conventional test Bayesian scores had a criterion correlation of .834, and the conventional test proportion-correct scores had a criterion correlation of .841.

A second trend seen is that for the conventional test, the proportion-correct scoring method resulted in scores that had a slightly higher criterion correlation than Bayesian scoring at all test lengths greater than three items. Across all test lengths, the average difference in the criterion correlation was .008, a small but consistent difference.

Figure 5
Alternate Forms Reliability of Ability Level Estimates for
the Bayesian Adaptive Test and for the Conventional Test
Scored by Proportion-Correct and Bayesian Scoring,
as a Function of the Number of Items Administered

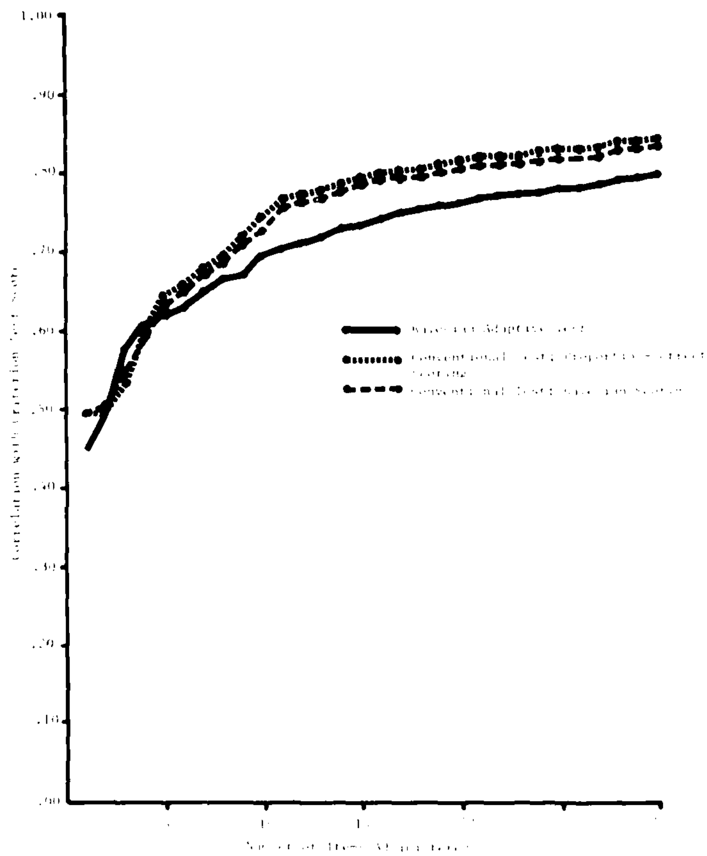


A final trend, which is seen in Figure 6, is that the largest criterion correlation difference between the Bayesian test and the conventional test (using either scoring system) occurred following the administration of the 11th item (.056 with Bayesian scores and .065 with the proportion-correct scores). For longer test lengths the two testing strategies resulted in increasingly similar criterion correlations until, after the last item was administered, the differences in the criterion correlations derived from the Bayesian testing strategy and the conventional testing strategy were .037 (scoring the conventional test by the Bayesian scoring method) and .044 (scoring the conventional test by the proportion-correct scoring method).

Discussion and Conclusions

The results of this study imply that with the subjects and item pools used the Bayesian adaptive testing strategy results in test scores that are more reliable and less valid than the scores derived from a conventional testing strategy for test lengths greater than about 10 items.

Figure 6
Correlations of Criterion Test Scores with Ability Level Estimates from the Bayesian Adaptive Test and the Conventional Test Scored by Proportion-Correct and Bayesian Scoring, as a Function of the Number of Items Administered (Averaged Across two Test Forms)



To more accurately reflect what has been done in this study, it is important to more closely examine two factors:

1. The correspondence of the alternate forms used for the analysis of alternate-forms reliability with the two testing strategies, and
2. The relative performance of the two scoring methods within the two forms of the conventional test.

Correspondence of Alternate Forms

Examination of the mean Bayesian ability level estimates obtained from Forms A and B for the two testing strategies (Figures 3 and 4) provides important information. The mean ability level estimates produced by the Bayesian test forms were less disparate than the Bayesian estimates produced by the conventional test forms at almost all test lengths. If perfectly parallel test forms were used, mean ability estimates would differ from one form to the other only by measurement error. With a suitably large testing sample, the mean ability estimates should converge to a common value. To the extent that two forms of a test result in different mean ability level estimates, (1) the two test forms have observable measurement error or (2) the two test forms were not perfectly parallel. Thus, the observation that the forms of the conventional test resulted in mean ability level estimates that were more disparate than those produced by the two forms of the Bayesian test can be attributed to either (1) the conventional test resulting in more measurement error than the Bayesian adaptive test or (2) the Bayesian test forms being closer to parallel than the conventional test forms. Either explanation is feasible, and the available data permit no method for gaining support for one explanation or the other.

It is possible, then, that as with the disparate mean ability estimates, the differential reliability of the scores derived from the two testing strategies can be attributed to either a true difference in the reliabilities of the scores derived from the two testing strategies or to differences in the approximation of the test forms to perfect parallelism. This possibility may limit the confidence that can be placed in the conclusion that the Bayesian testing strategy resulted in more reliable scores than the conventional testing strategy.

Scoring Methods

The second factor to be taken into account in qualifying the conclusions is the relative performance of the two scoring strategies applied to the two conventional test forms. It has been noted above that the Bayesian and proportion-correct scoring methods resulted in very similar alternate-forms reliability coefficients for the conventional test (as shown in Figure 5).

The Bayesian scoring algorithm uses the item parameter estimates along with the observed pattern of item responses to determine the ability level estimate for each individual. This procedure gives differential weightings to each of the individual's responses, depending on the parameter estimates for the items. To the extent that the items differ from one another in terms of their difficulties, and particularly in terms of their discriminations, these differential item response weightings should reduce the amount of measurement error expected in the individual's ability level estimate. This trend should result in higher alternate-forms reliability for a test when it is scored using the Bayesian procedure than when it is scored using the proportion of correct answers.

This result was not seen in this study, and the reason may be that the parameter estimates used contained too much error to allow the Bayesian scoring procedure to perform at a level of efficiency high enough to result in higher reliabilities than the proportion-correct procedure. This line of argument has been presented by Lord (1979) in a paper that limited itself to the one- and two-parameter logistic models and a maximum likelihood trait level estimator, but the argument is clearly generalizable. If the parameters of a model are estimated using a small group of individuals, the resulting parameter estimates might be sufficiently poor to obviate the gain in precision of measurement (and, hence, reliability) that should be observed with the use of a more sensitive scoring procedure (such as the Bayesian procedure).

For the present study, the mean calibration sample size used for determining the item a and b parameter estimates for the items used in the conventional and Bayesian tests was less than 200, ranging from 61 to 328 subjects. It is not clear whether the calibration sample sizes used were sufficient to adequately estimate the parameters of the response model used for the purposes of this study.

If the subject sample used to calibrate the items in this study was too small to allow calibration that was accurate enough to result in increased reliability with the conventional test, however, these inaccurate parameter estimates would also have affected the performance of the Bayesian testing strategy. If there were inaccuracy in the item parameters, the effect on the Bayesian test would be twofold, decreasing the efficiency of both the item selection procedure and the scoring system. This factor could have caused this study to underestimate the reliability and validity that could be obtained with the Bayesian testing procedure with more accurate item parameter estimates, resulting in greater differences in reliabilities and unknown differences in validities for the two testing strategies.

Method Variance

There is one additional explanation for the findings of this study, which assumes the accuracy of both the reliability and validity findings observed. This explanation assumes that the validity differential in favor of the conventional test is due to method variance, since both the *experimental conventional* test and the criterion test were conventional (i.e., nonadaptive tests). If conventional test scores tended to correlate higher with each other than with adaptive test scores due solely to characteristics of the conventional tests, the results of this study would be in accord with such a hypothesis. Both adaptive test theory and prior data suggest that adaptive tests have higher reliabilities than do conventional tests, and the data from this study support this contention. Similarly, a previous study (Thompson & Weiss, 1980), in which conventional tests were not used as a validity criterion, showed higher validities for adaptive tests than for conventional tests. Thus, the lower validities observed in this study for the adaptive tests could have resulted from method variance in the conventional test correlations. Such method variance may be due to the distributional characteristics of the conventional tests, to correlated errors, or to other aspects of the tests constructed and administered by the conventional strategy.

Thus, future research comparing the relative reliabilities and validities of conventional and adaptive testing strategies should carefully balance the correspondence between the alternate forms of the tests and should use large samples of subjects for the calibration of the items used as well as a research design and validity criterion that would minimize the potential effects of method variance on the results.

References

Betz, N. E., & Weiss, D. J. Empirical and simulation studies of flexilevel ability testing (Research Report 75-3). Minneapolis: University of Minnesota, Department of Psychology, Psychometric Methods Program, July 1975.

Bejar, I. I., & Weiss, D. J. A construct validation of adaptive achievement testing (Research Report 78-4). Minneapolis: University of Minnesota, Department of Psychology, Psychometric Methods Program, November 1978.

Birnbaum, A. Some latent trait models and their use in inferring an examinee's ability. In F. M. Lord & M. R. Novick, Statistical theories of mental test scores. Reading, MA: Addison-Wesley, 1968.

Jensema, C. J. The validity of Bayesian tailored testing. Educational and Psychological Measurement, 1974, 34, 757-766.

Jensema, C. J. A simple technique for estimating latent trait mental test parameters. Educational and Psychological Measurement, 1976, 36, 705-715.

Larkin, K. C., & Weiss, D. J. An empirical investigation of computer-administered pyramidal ability testing (Research Report 74-3). Minneapolis: University of Minnesota, Department of Psychology, Psychometric Methods Program, July 1974.

Lord, F. M. Practical applications of item characteristic curve theory. Journal of Educational Measurement, 1977, 14, 117-138.

Lord, F. M. A broad-range tailored test of verbal ability. Applied Psychological Measurement, 1977, 1, 95-100.

Lord, F. M. Small N justifies the Rasch Model. In D. J. Weiss (Ed.), Proceedings of the 1979 Computerized Adaptive Testing Conference. Minneapolis: University of Minnesota, Department of Psychology, Computerized Adaptive Testing Laboratory, 1980.

Lord, F. M., & Novick, M. R. Statistical theories of mental test scores. Reading, MA: Addison-Wesley, 1968.

McBride, J. R., & Weiss, D. J. A word knowledge item pool for adaptive ability measurement (Research Report 74-2). Minneapolis: University of Minnesota, Department of Psychology, Psychometric Methods Program, June 1974.

McBride, J. R., & Weiss, D. J. Some properties of a Bayesian adaptive ability testing strategy (Research Report 76-1). Minneapolis: University of Minnesota, Department of Psychology, Psychometric Methods Program, March 1976.

Owen, R. J. A Bayesian approach to tailored testing (Research Bulletin 69-92). Princeton, NJ: Educational Testing Service, 1969.

Owen, R. J. A Bayesian sequential procedure for quantal response in the context of adaptive mental testing. Journal of the American Statistical Association, 1975, 70, 351-356.

Prestwood, J. S., & Weiss, D. J. Accuracy of perceived test-item difficulties (Research Report 77-3). Minneapolis: University of Minnesota, Department of Psychology, Psychometric Methods Program, May 1977.

Thompson, J. G., & Weiss, D. J. Criterion-related validity of adaptive testing strategies (Research Report 80-3). Minneapolis: University of Minnesota, Department of Psychology, Psychometric Methods Program, June 1980.

Urry, V. W. Individualized testing by Bayesian estimation (Research Bulletin 0171-177). Seattle: University of Washington, Bureau of Testing, April 1971.

Urry, V. W. Tailored testing: A successful application of latent trait theory. Journal of Educational Measurement, 1977, 14, 181-196.

Weiss, D. J. Strategies of adaptive ability measurement (Research Report 74-5). Minneapolis: University of Minnesota, Department of Psychology, Psychometric Methods Program, December 1974.

Weiss, D. J., & Betz, N. E. Ability measurement: Conventional or adaptive? (Research Report 73-1). Minneapolis: University of Minnesota, Department of Psychology, Psychometric Methods Program, February 1973.

APPENDIX: SUPPLEMENTARY TABLES

Table A
Item Parameter Estimates for Items on the Criterion Test

Item	a	b	c	Item	a	b	c	Item	a	b	c
1	.830	-2.852	.130	41	1.132	.182	.191	81	.821	-.158	.139
2	.421	-.820	.130	42	1.935	.540	.253	82	1.193	.638	.139
3	1.039	-1.009	.199	43	1.151	-.318	.150	83	2.101	-.069	.194
4	.900	-1.804	.130	44	.135	4.558	.150	84	.957	-.038	.139
5	.621	-.945	.130	45	1.183	-.026	.100	85	1.061	.406	.150
6	1.173	-1.014	.130	46	.505	.601	.150	86	1.869	-.038	.181
7	.394	-.033	.130	47	.908	.001	.150	87	2.104	.831	.054
8	1.381	.860	.305	48	1.623	.430	.183	88	1.157	.526	.111
9	1.373	-.332	.199	49	1.726	.516	.197	89	1.882	1.471	.197
10	1.862	.147	.084	50	.516	-.691	.150	90	2.104	1.271	.170
11	.740	-1.717	.130	51	1.128	.643	.203	91	.593	-2.830	.150
12	1.472	.816	.167	52	1.611	.291	.150	92	1.289	-1.394	.150
13	.899	-.020	.198	53	.814	.176	.150	93	.742	-.918	.150
14	1.862	.992	.316	54	.605	.822	.150	94	.765	-2.267	.150
15	.544	-.437	.130	55	1.699	1.048	.184	95	1.047	-1.009	.150
16	1.862	.383	.197	56	1.935	.856	.100	96	1.588	-.416	.196
17	1.611	.799	.130	57	.555	.674	.150	97	1.302	-.913	.150
18	1.378	.352	.130	58	.747	.085	.115	98	1.347	-1.569	.150
19	1.282	.692	.179	59	1.935	1.888	.122	99	.605	-2.075	.150
20	1.862	.522	.061	60	1.935	1.255	.110	100	1.034	-.266	.150
21	.892	.376	.191	61	.908	-2.746	.139	101	.884	-1.016	.150
22	1.862	1.906	.147	62	.737	-2.463	.139	102	1.068	.535	.195
23	1.339	.225	.174	63	.516	-3.818	.139	103	1.285	-.003	.150
24	1.259	1.147	.199	64	1.114	-.952	.139	104	1.281	-1.168	.150
25	1.523	.898	.089	65	.718	-1.288	.139	105	1.083	-.062	.150
26	1.862	.983	.130	66	.732	-.817	.150	106	.501	-.872	.150
27	.574	1.119	.150	67	1.604	-.983	.139	107	1.123	-.250	.150
28	1.758	1.375	.187	68	1.498	-.888	.139	108	1.679	-.279	.195
29	1.045	1.662	.092	69	1.005	-1.084	.139	109	.713	-.883	.150
30	1.862	2.620	.169	70	1.226	-.250	.179	110	1.557	-.299	.150
31	.675	-2.523	.150	71	.993	-.991	.139	111	1.217	.724	.204
32	.882	-2.584	.150	72	1.074	-.697	.139	112	.877	-.387	.100
33	.564	-1.805	.150	73	1.914	-.355	.254	113	1.355	.697	.210
34	.745	-1.721	.150	74	1.513	-.429	.169	114	1.088	-.027	.150
35	1.076	-.285	.150	75	.697	-1.095	.139	115	1.595	.177	.115
36	1.776	.589	.150	76	.991	-.618	.150	116	1.782	-.397	.195
37	.757	-.070	.150	77	2.104	.054	.210	117	1.312	.243	.182
38	.950	-.098	.150	78	1.931	.047	.139	118	.925	-.413	.100
39	1.908	.182	.210	79	2.104	.433	.248	119	1.745	1.330	.171
40	1.935	-.271	.150	80	1.105	-.545	.081	120	2.161	1.430	.071

Table B
Item Parameter Estimates for Items from
Alternate Forms A and B of the Conventional Test
in Order of Administration ($\underline{c}$=.20 for All Items)

Item	Form	$\underline{a}$	$\underline{b}$	Item	Form	$\underline{a}$	$\underline{b}$
1	A	3.000	.276	31	B	1.093	.601
2	B	1.634	.158	32	A	1.043	-.962
3	B	1.627	.289	33	A	.831	.171
4	A	1.223	-.138	34	B	.933	.467
5	A	1.131	-.197	35	B	.823	-.559
6	B	2.120	.509	36	A	.793	-.034
7	B	1.644	-.789	37	A	.887	.401
8	A	1.854	.523	38	B	1.438	.701
9	A	1.061	-.393	39	B	.771	-.409
10	B	1.241	-.763	40	A	.742	-.179
11	B	1.594	.544	41	A	1.057	.678
12	A	.972	-.396	42	B	.758	-.677
13	A	3.000	.486	43	B	.728	-.452
14	B	2.275	.549	44	A	.712	-.527
15	B	.943	.050	45	A	.730	.218
16	A	1.180	.518	46	B	1.264	.786
17	A	.922	-.524	47	B	.701	-.544
18	B	.876	-.105	48	A	.814	.579
19	B	1.107	-.861	49	A	3.000	.572
20	A	.856	-.198	50	B	.680	-.690
21	A	.977	-.754	51	B	.658	.011
22	B	1.790	-.959	52	A	.649	-.131
23	B	.856	-.010	53	A	.652	-.499
24	A	.853	-.380	54	B	.722	.515
25	A	.841	-.166	55	B	.637	-.478
26	B	.872	.176	56	A	1.002	.850
27	B	.840	-.364	57	A	.623	.000
28	A	.983	.478	58	B	1.087	.885
29	A	.939	.413	59	B	.620	.058
30	B	.820	-.384	60	A	.603	-.385

Table C
Item Parameter Estimates for Items in the Bayesian Adaptive Testing Item Pool
(c=.20 for All Items)

Item	a	b	Item	a	b	Item	a	b	Item	a	b
1	1.960	.223	46	.745	.311	91	3.000	1.381	136	1.075	-1.345
2	1.529	-.146	47	.689	-.050	92	3.000	1.374	137	1.067	-1.335
3	1.424	.176	48	.678	-.257	93	3.000	1.860	138	.943	-1.313
4	1.384	.131	49	.681	-.684	94	2.321	1.442	139	.875	-1.448
5	1.202	-.550	50	.669	-.567	95	2.111	1.518	140	.887	-1.189
6	1.109	.135	51	.651	-.173	96	3.000	1.945	141	2.128	-1.790
7	1.073	-.355	52	.693	.321	97	1.716	1.420	142	1.887	-1.552
8	1.036	-.152	53	.674	.242	98	1.618	1.506	143	1.701	-1.640
9	1.200	.351	54	.712	.470	99	1.380	1.515	144	1.728	-2.022
10	1.375	.468	55	.664	-.776	100	1.289	1.433	145	1.427	-1.674
11	1.570	.546	56	.886	.796	101	3.000	.960	146	1.235	-1.875
12	1.109	-.701	57	.959	.858	102	3.000	1.000	147	1.200	-1.970
13	3.000	.486	58	1.210	.875	103	3.000	1.017	148	1.128	-1.722
14	.939	-.281	59	.619	-.655	104	3.000	1.064	149	1.083	-1.996
15	.949	-.439	60	.610	.012	105	3.000	.792	150	1.067	-1.936
16	1.244	.542	61	3.000	2.287	106	3.000	1.156	151	.873	-2.016
17	.917	.171	62	3.000	2.363	107	3.000	1.180	152	.829	-1.582
18	1.086	.483	63	3.000	2.405	108	3.000	.670	153	.768	-1.927
19	.872	-.124	64	3.000	2.138	109	2.778	1.171	154	.745	-2.158
20	.860	-.235	65	3.000	2.138	110	3.000	1.219	155	.812	-1.244
21	.934	-.670	66	3.000	2.138	111	2.291	.765	156	.722	-2.141
22	.870	.067	67	2.935	2.411	112	3.000	1.244	157	.692	-2.144
23	.910	-.633	68	3.000	2.069	113	3.000	1.259	158	.672	-2.009
24	.939	-.709	69	3.000	2.066	114	1.843	.780	159	.757	-1.191
25	.910	.286	70	3.000	2.066	115	1.765	1.161	160	.663	-1.781
26	1.069	.536	71	3.000	2.066	116	1.314	1.097	161	3.000	-2.363
27	.872	.195	72	3.000	2.504	117	1.267	1.113	162	3.000	-2.363
28	.822	-.278	73	3.000	2.022	118	1.317	1.204	163	3.000	-2.324
29	.896	.336	74	3.000	2.022	119	1.168	.919	164	3.000	-2.324
30	1.232	.643	75	3.000	2.632	120	1.256	1.207	165	3.000	-2.632
31	.844	.205	76	3.000	2.632	121	1.432	-1.043	166	3.000	-2.632
32	.860	.275	77	1.162	2.676	122	1.235	-1.031	167	3.000	-2.632
33	.797	-.257	78	.632	2.153	123	1.093	-1.093	168	2.208	-2.461
34	.876	-.742	79	.613	2.004	124	.882	-1.061	169	1.749	-2.366
35	.800	-.390	80	.556	1.991	125	.835	-1.022	170	1.753	-2.580
36	1.058	-.998	81	3.000	1.606	126	.777	-1.055	171	1.452	-2.239
37	.791	.085	82	3.000	1.576	127	.736	-1.085	172	1.286	-2.236
38	.773	-.235	83	3.000	1.709	128	.672	-1.091	173	1.241	-2.670
39	.767	-.374	84	3.000	1.481	129	.568	-1.054	174	1.087	-2.635
40	.876	-.924	85	3.000	1.472	130	.564	-1.023	175	1.104	-2.187
41	.779	.246	86	3.000	1.758	131	1.817	-1.439	176	1.020	-2.584
42	.788	.295	87	3.000	1.464	132	1.749	-1.256	177	1.014	-2.479
43	.745	-.684	88	3.000	1.455	133	1.274	-1.351	178	.981	-2.634
44	.767	-.803	89	3.000	1.801	134	1.165	-1.395	179	.956	-2.266
45	.699	-.324	90	2.518	1.607	135	1.145	-1.412	180	.859	-2.251

Table D
Correlations Between Scores from Alternate Forms for Three Combinations of Testing Strategy and Test Scoring, at Test Lengths from 1 to 30 Items

Test Length	Bayesian Adaptive Test	Conventional Test: Bayesian Scoring	Conventional Test: Proportion-Correct Scoring
1	.211	.288	.288
2	.293	.374	.352
3	.446	.422	.419
4	.551	.454	.467
5	.568	.536	.534
6	.599	.566	.562
7	.638	.624	.613
8	.678	.649	.626
9	.698	.662	.652
10	.706	.703	.696
11	.738	.724	.723
12	.759	.737	.734
13	.780	.754	.757
14	.791	.763	.764
15	.810	.774	.780
16	.812	.790	.795
17	.830	.801	.808
18	.835	.807	.812
19	.844	.823	.822
20	.851	.831	.831
21	.864	.837	.837
22	.872	.840	.838
23	.877	.841	.842
24	.885	.842	.845
25	.892	.850	.857
26	.896	.854	.861
27	.906	.856	.864
28	.911	.860	.869
29	.915	.861	.871
30	.920	.868	.879

Table E
Correlations Between Criterion Test Scores and Scores Obtained from Three Combinations of Testing Strategy and Scoring Method at Test Lengths from 1 to 30 Items, Averaged Across Test Forms

Test Length	Bayesian Adaptive Test	Conventional Test: Bayesian Scoring	Conventional Test: Proportion-Correct Scoring
1	.445	.492	.492
2	.490	.501	.493
3	.576	.543	.536
4	.610	.590	.597
5	.621	.635	.644
6	.630	.653	.657
7	.650	.676	.680
8	.665	.688	.693
9	.671	.710	.720
10	.691	.729	.741
11	.702	.758	.767
12	.712	.764	.772
13	.720	.769	.781
14	.729	.776	.787
15	.735	.782	.792
16	.741	.791	.801
17	.750	.795	.805
18	.755	.797	.807
19	.758	.803	.812
20	.763	.808	.818
21	.768	.810	.820
22	.771	.813	.824
23	.775	.814	.823
24	.776	.818	.828
25	.779	.820	.832
26	.783	.820	.830
27	.786	.822	.833
28	.790	.827	.840
29	.795	.833	.840
30	.797	.834	.841

DISTRIBUTION LIST

Navy

1 Dr. Ed Aiken
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Jack R. Borsting
Provost & Academic Dean
U.S. Naval Postgraduate School
Monterey, CA 93940

1 Dr. Robert Breaux
Code N-711
NAVTRAEQUIPCEN
Orlando, FL 32813

1 Chief of Naval Education and Training
Liason Office
Air Force Human Resource Laboratory
Flying Training Division
WILLIAMS AFB, AZ 85224

1 Dr. Richard Elster
Department of Administrative Sciences
Naval Postgraduate School
Monterey, CA 93940

1 DR. PAT FEDERICO
NAVY PERSONNEL R&D CENTER
SAN DIEGO, CA 92152

1 Mr. Paul Foley
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. John Ford
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Henry M. Halff
Department of Psychology, C-009
University of California at San Diego
La Jolla, CA 92093

1 Dr. Patrick R. Harrison
Psychology Course Director
LEADERSHIP & LAW DEPT. (7b)
DIV. OF PROFESSIONAL DEVELOPMMENT
U.S. NAVAL ACADEMY
ANNAPOLIS, MD 21402

1 CDR Robert S. Kennedy
Head, Human Performance Sciences
Naval Aerospace Medical Research Lab
Box 29407
New Orleans, LA 70189

1 Dr. Norman J. Kerr
Chief of Naval Technical Training
Naval Air Station Memphis (75)
Millington, TN 38054

1 Dr. William L. Maloy
Principal Civilian Advisor for
Education and Training
Naval Training Command, Code 00A
Pensacola, FL 32508

1 Dr. Kneale Marshall
Scientific Advisor to DCNO(MPT)
OP01T
Washington DC 20370

1 CAPT Richard L. Martin, USN
Prospective Commanding Officer
USS Carl Vinson (CVN-70)
Newport News Shipbuilding and
Drydock Co
Newport News, VA 23607

1 Dr. James McBride
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr William Montague
Navy Personnel R&D Center
San Diego, CA 92152

1 Library
Naval Health Research Center
P. O. Box 85122
San Diego, CA 92138

1 Naval Medical R&D Command
Code 44
National Naval Medical Center
Bethesda, MD 20014

1 Ted M. I. Yellen
Technical Information Office, Code 201
NAVY PERSONNEL R&D CENTER
SAN DIEGO, CA 92152

1 Library, Code P201L
Navy Personnel R&D Center
San Diego, CA 92152

6 Commanding Officer
Naval Research Laboratory
Code 2627
Washington, DC 20390

1 Psychologist
ONR Branch Office
Bldg 114, Section D
666 Summer Street
Boston, MA 02210

1 Psychologist
ONR Branch Office
536 S. Clark Street
Chicago, IL 60605

1 Office of Naval Research
Code 437
800 N. Quincy SStreet
Arlington, VA 22217

5 Personnel & Training Research Programs
(Code 458)
Office of Naval Research
Arlington, VA 22217

1 Psychologist
ONR Branch Office
1030 East Green Street
Pasadena, CA 91101

1 Office of the Chief of Naval Operations
Research Development & Studies Branch
(OP-115)
Washington, DC 20350

1 LT Frank C. Petho, MSC, USN (Ph.D)
Code L51
Naval Aerospace Medical Research Laborat
Pensacola, FL 32508

1 Roger W. Remington, Ph.D
Code L52
NAMRL
Pensacola, FL 32508

1 Dr. Bernard Rimland (03B)
Navy Personnel R&D Center
San Diego, CA 92152

1 Mr. Arnold Rubenstein
Naval Personnel Support Technology
Naval Material Command (08T244)
Room 1044, Crystal Plaza #5
2221 Jefferson Davis Highway
Arlington, VA 20360

1 Dr. Worth Scanland
Chief of Naval Education and Training
Code N-5
NAS, Pensacola, FL 32508

1 Dr. Robert G. Smith
Office of Chief of Naval Operations
OP-987H
Washington, DC 20350

1 Dr. Alfred F. Smode
Training Analysis & Evaluation Group
(TAEG)
Dept. of the Navy
Orlando, FL 32813

1 Dr. Richard Sorensen
Navy Personnel R&D Center
San Diego, CA 92152

1 W. Gary Thomson
Naval Ocean Systems Center
Code 7132
San Diego, CA 92152

1 Dr. Ronald Weitzman
Code 54 WZ
Department of Administrative Sciences
U. S. Naval Postgraduate School
Monterey, CA 93940

1 DR. MARTIN F. WISKOFF
NAVY PERSONNEL R& D CENTER
SAN DIEGO, CA 92152

Army

1 Technical Director
U. S. Army Research Institute for the
Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

1 HQ USAREUE & 7th Army
ODCSOPS
USAAREUE Director of GED
APO New York 09403

1 DR. RALPH DUSEK
U.S. ARMY RESEARCH INSTITUTE
5001 EISENHOWER AVENUE
ALEXANDRIA, VA 22333

1 Dr. Myron Fischl
U.S. Army Research Institute for the
Social and Behavioral Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

1 Dr. Michael Kaplan
U.S. ARMY RESEARCH INSTITUTE
5001 EISENHOWER AVENUE
ALEXANDRIA, VA 22333

1 Dr. Milton S. Katz
Training Technical Area
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

1 Dr. Harold F. O'Neil, Jr.
Attn: PERI-OK
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

1 Mr. Robert Ross
U.S. Army Research Institute for the
Social and Behavioral Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

1 Dr. Robert Sasmor
U. S. Army Research Institute for the
Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

1 Commandant
US Army Institute of Administration
Attn: Dr. Sherrill
FT Benjamin Harrison, IN 46256

1 Dr. Frederick Steinheiser
U. S. Army Reserch Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

1 Dr. Joseph Ward
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Air Force

1 Air Force Human Resources Lab
AFHRL/MPD
Brooks AFB, TX 78235

1 Air University Library
AUL/LSE 76/443
Maxwell AFB, AL 36112

1 Dr. Earl A. Alluisi
HQ, AFHRL (AFSC)
Brooks AFB, TX 78235

1 Dr. Genevieve Haddad
Program Manager
Life Sciences Directorate
AFOSR
Bolling AFB, DC 20332

1 Dr. Ross L. Morgan (AFHRL/LR)
Wright -Patterson AFB
Ohio 45433

1 Research and Measurment Division
Research Branch, AFMPC/MPCYPR
Randolph AFB, TX 78148

1 Dr. Malcolm Ree
AFHRL/MP
Brooks AFB, TX 78235

1 Dr. Marty Rockway
Technical Director
AFHRL(OT)
Williams AFB, AZ 58224

1 Jack A. Thorp, Maj., USAF
Life Sciences Directorate
AFOSR
Bolling AFB, DC 20332

Marines

1 H. William Greenup
Education Advisor (E031)
Education Center, MCDEC
Quantico, VA 22134

1 Director, Office of Manpower
Utilization
HQ, Marine Corps (MPU)
BCB, Bldg. 2009
Quantico, VA 22134

1 DR. A.L. SLAFKOSKY
SCIENTIFIC ADVISOR (CODE RD-1)
HQ, U.S. MARINE CORPS
WASHINGTON, DC 20380

CoastGuard

1 Mr. Thomas A. Warm
U. S. Coast Guard Institute
P. O. Substation 18
Oklahoma City, OK 73169

Other DoD

12 Defense Technical Information Center
Cameron Station, Bldg 5
Alexandria, VA 22314
Attn: TC

1 Dr. Dexter Fletcher
ADVANCED RESEARCH PROJECTS AGENCY
1400 WILSON BLVD.
ARLINGTON, VA 22209

1 Dr. William Graham
Testing Directorate
MEPCOM/MEPCT-P
Ft. Sheridan, IL 60037

1 Military Assistant for Training and
Personnel Technology
Office of the Under Secretary of Defense
for Research & Engineering
Room 3D129, The Pentagon
Washington, DC 20301

1 MAJOR Wayne Sellman, USAF
Office of the Assistant Secretary
of Defense (MRA&L)
3B930 The Pentagon
Washington, DC 20301

1 HEAD, SECTION [illegible]
UNIFORMED SERVICES UNIV. OF THE
HEALTH SCIENCES
6917 ARLINGTON ROAD
BETHESDA, MD [illegible]

Civil Govt

1 Dr. Susan Chipman
Learning and Development
National Institute of Education
1200 19th Street NW
Washington, DC [illegible]

1 Dr. Joseph I. Lipson
SEDR W-6[illegible]
National Science Foundation
Washington, DC 20550

1 Dr. John Mays
National Institute of Education
1200 19th Street NW
Washington, DC 20208

1 Dr. Arthur Melmed
National Intitute of Education
1200 19th Street NW
Washington, DC 20208

1 Dr. Andrew R. Molnar
Science Education Dev.
and Research
National Science Foundation
Washington, DC 20550

1 Personnel R&D Center
Office of Personnel Managment
1900 E Street NW
Washington, DC 20415

1 Dr. Vern W. Urry
Personnel R&D Center
Office of Personnel Management
1900 E Street NW
Washington, DC 20415

1 Dr. Joseph L. Young, Director
Memory & Cognitive Processes
National Science Foundation
Washington, DC 20550

Non Govt

1 Dr. Erling B. Andersen
Department of Statistics
Studiestraede 6
1455 Copenhagen
DENMARK

1 1 psychological research unit
Dept. of Defense (Army Office)
Campbell Park Offices
Canberra ACT 2600, Australia

1 Dr. Alan Baddeley
Medical Research Council
Applied Psychology Unit
15 Chaucer Road
Cambridge CB2 2EF
ENGLAND

1 Dr. Isaac Bejar
Educational Testing Service
Princeton, NJ 08450

1 Dr. Werner Birke
DezWPs im Streitkraefteamt
Postfach 20 50 03
D-5300 Bonn 2
WEST GERMANY

1 Dr. Nicholas A. Bond
Dept. of Psychology
Sacramento State College
600 Jay Street
Sacramento, CA 95819

1 Dr. David G. Bowers
Institute for Social Research
University of Michigan
P. O. Box 1248
Ann Arbor, MI 48106

1 Dr. Robert Brennan
American College Testing Programs
P. O. Box 168
Iowa City, IA 52240

1 DR. C. VICTOR BUNDERSON
WICAT INC.
UNIVERSITY PLAZA, SUITE 10
1160 SO. STATE ST.
OREM, UT 84057

1 Dr. John B. Carroll
Psychometric Lab
Univ. of No. Carolina
Davie Hall 013A
Chapel Hill, NC 27514

1 Charles Myers Library
Livingstone House
Livingstone Road
Stratford
London E15 2LJ
ENGLAND

1 Dr. Kenneth E. Clark
College of Arts & Sciences
University of Rochester
River Campus Station
Rochester, NY 14627

1 Dr. Norman Cliff
Dept. of Psychology
Univ. of So. California
University Park
Los Angeles, CA 90007

1 Dr. William E. Coffman
Director, Iowa Testing Programs
334 Lindquist Center
University of Iowa
Iowa City, IA 52242

1 Dr. Allan M. Collins
Bolt Beranek & Newman, Inc.
50 Moulton Street
Cambridge, Ma 02138

1 Dr. Meredith P. Crawford
American Psychological Association
1200 17th Street, N.W.
Washington, DC 20036

1 Dr. Hans Crombag
Education Research Center
University of Leyden
Boerhaavelaan 2
2334 EN Leyden
The NETHERLANDS

1 LCOL J. C. Eggenberger
DIRECTORATE OF PERSONNEL APPLIED RESEARCH
NATIONAL DEFENCE HQ
101 COLONEL BY DRIVE
OTTAWA, CANADA K1A 0K2

1 Dr. Leonard Feldt
Lindquist Center for Measurment
University of Iowa
Iowa City, IA 52242

1 Dr. Richard L. Ferguson
The American College Testing Program
P.O. Box 168
Iowa City, IA 52240

1 Dr. Victor Fields
Dept. of Psychology
Montgomery College
Rockville, MD 20850

1 Univ. Prof. Dr. Gerhard Fischer
Liebiggasse 5/3
A 1010 Vienna
AUSTRIA

1 Professor Donald Fitzgerald
University of New England
Armidale, New South Wales 2351
AUSTRALIA

1 Dr. Edwin A. Fleishman
Advanced Research Resources Organ.
Suite 900
4330 East West Highway
Washington, DC 20014

1 Dr. John R. Frederiksen
Bolt Beranek & Newman
50 Moulton Street
Cambridge, MA 02138

1 DR. ROBERT GLASER
LRDC
UNIVERSITY OF PITTSBURGH
3939 O'HARA STREET
PITTSBURGH, PA 15213

1 Dr. Ron Hambleton
School of Education
University of Massechusetts
Amherst, MA 01002

1 Dr. Chester Harris
School of Education
University of California
Santa Barbara, CA 93106

1 Dr. Lloyd Humphreys
Department of Psychology
University of Illinois
Champaign, IL 61820

Library
HumRRO/Western Division
27857 Berwick Drive
Carmel, CA 93921

1 Dr. Steven Hunka
Department of Education
University of Alberta
Edmonton, Alberta
CANADA

1 Dr. Earl Hunt
Dept. of Psychology
University of Washington
Seattle, WA [illegible]

1 Dr. Huynh Huynh
College of Education
University of South Carolina
Columbia, SC 29208

1 Dr. Douglas H. Jones
Rm T-255
Educational Testing Service
Princeton, NJ 08450

1 Professor John A. Keats
University of Newcastle
AUSTRALIA 2308

1 Dr. Mazie Knerr
Litton-Mellonics
Box 1286
Springfield, VA 22151

1 Mr. Marlin Kroger
1117 Via Goleta
Palos Verdes Estates, CA 90274

1 Dr. Michael Levine
Department of Educational Psychology
210 Education Bldg.
University of Illinois
Champaign, IL 61801

1 Dr. Charles Lewis
Faculteit Sociale Wetenschappen
Rijksuniversiteit Groningen
Oude Boteringestraat
Groningen
NETHERLANDS

1 Dr. Robert Linn
College of Education
University of Illinois
Urbana, IL 61801

1 Dr. Frederick M. Lord
Educational Testing Service
Princeton, NJ 08540

1 Dr. Gary Marco
Educational Testing Service
Princeton, NJ 08450

1 Dr. Scott Maxwell
Department of Psychology
University of Houston
Houston, TX 77004

1 Dr. Samuel T. Mayo
Loyola University of Chicago
820 North Michigan Avenue
Chicago, IL 60611

1 Dr. Allen Munro
Behavioral Technology Laboratories
1845 Elena Ave., Fourth Floor
Redondo Beach, CA 90277

1 Dr. Melvin R. Novick
356 Lindquist Center for Measurment
University of Iowa
Iowa City, IA 52242

1 Dr. Jesse Orlansky
Institute for Defense Analyses
400 Army Navy Drive
Arlington, VA 22202

1 Dr. James A. Paulson
Portland State University
P.O. Box 751
Portland, OR 97207

1 MR. LUIGI PETRULLO
2431 N. EDGEWOOD STREET
ARLINGTON, VA 22207

1 DR. DIANE M. RAMSEY-KLEE
R-K RESEARCH & SYSTEM DESIGN
3947 RIDGEMONT DRIVE
MALIBU, CA 90265

1 MINRAT M. L. RAUCH
P II 4
BUNDESMINISTERIUM DER VERTEIDIGUNG
POSTFACH 1328
D-53 BONN 1, GERMANY

1 Dr. Mark D. Reckase
Educational Psychology Dept.
University of Missouri-Columbia
4 Hill Hall
Columbia, MO 65211

1 Dr. Fred Reif
SESAME
c/o Physics Department
University of California
Berkely, CA 94720

1 Dr. Andrew M. Rose
American Institutes for Research
1055 Thomas Jefferson St. NW
Washington, DC 20007

1 Dr. Leonard L. Rosenbaum, Chairman
Department of Psychology
Montgomery College
Rockville, MD 20850

1 Dr. Ernst Z. Rothkopf
Bell Laboratories
600 Mountain Avenue
Murray Hill, NJ 07974

1 Dr. Lawrence Rudner
403 Elm Avenue
Takoma Park, MD 20012

1 Dr. J. Ryan
Department of Education
University of South Carolina
Columbia, SC 29208

1 PROF. FUMIKO SAMEJIMA
DEPT. OF PSYCHOLOGY
UNIVERSITY OF TENNESSEE
KNOXVILLE, TN 37916

1 DR. ROBERT J. SEIDEL
INSTRUCTIONAL TECHNOLOGY GROUP
HUMRRO
300 N. WASHINGTON ST.
ALEXANDRIA, VA 22314

1 Committee on Cognitive Research
% Dr. Lonnie R. Sherrod
Social Science Research Council
605 Third Avenue
New York, NY 10016

1 Dr. Kazuo Shigemasu
University of Tohoku
Department of Educational Psychology
Kawauchi, Sendai 980
JAPAN

1 Dr. Edwin Shirkey
Department of Psychology
University of Central Florida
Orlando, FL 32816

1 Dr. Robert Smith
Department of Computer Science
Rutgers University
New Brunswick, NJ 08903

1 Dr. Richard Snow
School of Education
Stanford University
Stanford, CA 94305

1 Dr. Robert Sternberg
Dept. of Psychology
Yale University
Box 11A, Yale Station
New Haven, CT 06520

1 DR. ALBERT STEVENS
BOLT BERANEK & NEWMAN, INC.
50 MOULTON STREET
CAMBRIDGE, MA 02138

1 DR. PATRICK SUPPES
INSTITUTE FOR MATHEMATICAL STUDIES IN
THE SOCIAL SCIENCES
STANFORD UNIVERSITY
STANFORD, CA 94305

1 Dr. Hariharan Swaminathan
Laboratory of Psychometric and
Evaluation Research
School of Education
University of Massachusetts
Amherst, MA 01003

1 Dr. Brad Sympson
Psychometric Research Group
Educational Testing Service
Princeton, NJ 08541

1 Dr. Kikumi Tatsuoka
Computer Based Education Research
Laboratory
252 Engineering Research Laboratory
University of Illinois
Urbana, IL 61801

1 Dr. David Thissen
Department of Psychology
University of Kansas
Lawrence, KS 66044

1 Dr. Robert Tsutakawa
Department of Statistics
University of Missouri
Columbia, MO 65201

1 Dr. J. Uhlaner
Perceptronics, Inc.
6271 Variel Avenue
Woodland Hills, CA 91364

1 Dr. Howard Wainer
Bureau of Social Science Research
1990 M Street, N. W.
Washington, DC 20036

1 DR. THOMAS WALLSTEN
PSYCHOMETRIC LABORATORY
DAVIE HALL 013A
UNIVERSITY OF NORTH CAROL
CHAPEL HILL, NC 27514

1 Dr. Phyllis Weaver
Graduate School of Education
Harvard University
200 Larsen Hall, Appian Way
Cambridge, MA 02138

1 DR. SUSAN E. WHITELY
PSYCHOLOGY DEPARTMENT
UNIVERSITY OF KANSAS
LAWRENCE, KANSAS 66044

1 Wolfgang Wildgrube
Streitkraefteamt
Box 20 50 03
D-5300 Bonn 2
WEST GERMANY

1 Dr. Karl Zinn
Center for research on Learning
and Teaching
University of Michigan
Ann Arbor, MI 48104

DAT
FILM